Project AIR FORCE

Supporting Expeditionary Aerospace Forces

A Concept for Evolving the Agile Combat Support/Mobility System of the Future

Robert S. Tripp
Lionel Galway
Timothy L. Ramey
Mahyar Amouzegar
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RAND

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PREFACE

This report, one of a series of RAND publications that address Agile Combat Support (ACS) issues in implementing the Expeditionary Aerospace Force (EAF), summarizes RAND work to date on designing and evaluating the future ACS and mobility system that is needed to meet EAF operational objectives. Design decisions involve tradeoffs among system characteristics such as those between employment timelines and costs.

Other publications in the series address planning, practices, policies, and technologies that can enhance EAF effectiveness (see Tripp et al., *Supporting Expeditionary Aerospace Forces: An Integrated Strategic Agile Combat Support Planning Framework*, MR-1056-AF, 1999), support of emerging U.S. Air Force employment strategies (see Galway et al., *Supporting Expeditionary Aerospace Forces: New Agile Combat Support Postures*, MR-1075-AF, 2000), and the need for a strategy to deploy and employ forces in the face of uncertainty regarding overseas operating locations (see Killingsworth et al., *Flexbasing: Achieving Global Presence for Expeditionary Aerospace Forces*, MR-1113-AF, 2000).

This research, conducted in Project AIR FORCE's Resource Management Program, is sponsored by the Air Force Deputy Chief of Staff for Installations and Logistics (AF/IL). It is part of a larger project entitled "Evaluating Agile Combat Support Options for Implementing the Expeditionary Air Force." The report should be of interest to logisticians, operators, and mobility planners throughout the Air Force.

PROJECT AIR FORCE

Project AIR FORCE, a division of RAND, is the Air Force federally funded research and development center (FFRDC) for studies and analysis. It provides the Air Force with independent analyses of policy alternatives affecting the development, employment, combat readiness, and support of current and future aerospace forces. Research is performed in four programs: Aerospace Force Development; Manpower, Personnel, and Training; Resource Management; and Strategy and Doctrine.

CONTENTS

Preface iii

Figures vii

Summary ix

Acknowledgments xiii

Acronyms xv

Chapter One
- INTRODUCTION 1
- The EAF Challenge to the ACS/Mobility System 3
- Analytic Framework for Strategic ACS/Mobility Planning 4

Chapter Two
- THE ACS/MOBILITY SYSTEM DESIGN TRADE SPACE . . . 7

Chapter Three
- KEY FINDINGS 21

Chapter Four
- OVERVIEW OF A GLOBAL ACS/MOBILITY SYSTEM 25

Chapter Five
- STRATEGIC AND LONG-TERM PLANNING FOR THE ACS/MOBILITY SYSTEM 29

Bibliography 33

FIGURES

1.1.	Employment-Driven Analytical Framework	5
2.1.	Spin-Up Time as a Function of Resource Location	8
2.2.	Deployment Footprint as a Function of Resource Location	9
2.3.	Cost of Heavy Bomb Bodies "Invested" in Each Support Option	10
2.4.	Tradeoff Between Spin-Up Time and Investment Cost	11
2.5.	Small Munitions Characteristics	12
2.6.	Effect of the Small Smart Munition on Spin-Up Time and Deployment Footprint	13
2.7.	Personnel Deployment Requirements for F-15 Avionics Support Options	14
2.8.	Empirical and Theoretical Resupply Times for Various DoD Transportation Channels	17
3.1.	Cost/Timeline Resource Allocation Tradeoff	22
4.1.	Notional Global ACS Network	26
4.2.	A Notional FOL/FSL Configuration to Support the Caucasus Region	27
5.1.	A Structured Modeling Framework for Integrated ACS/Mobility Decisions	30
5.2.	Notional Tradeoff Analysis	31

SUMMARY

The Air Force has begun to reorganize into an Expeditionary Aerospace Force (EAF). The main thrust of that reorganization is to replace the forward presence of airpower with a force that can deploy quickly from the continental United States (CONUS) and other peacetime beddown locations in response to a crisis, commence operations immediately on arrival, and sustain those operations as needed. The success of the EAF will be largely dependent upon the effectiveness of the design of the Agile Combat Support (ACS) and mobility systems.

Early EAF implementation discussions of support resources focused on deploying unit preparation with the intent of paring unit resources to enable the deploying forces to be "light, lethal, and self-contained," or at least self-sustaining for the first few days. As our research pointed out, however, most resources that are needed to initiate and sustain combat operations, such as munitions, fuel, and War Reserve Materiel (WRM: portable shelters, ground support equipment, vehicles, etc.), are not unit-level resources. These resources are heavy and usually positioned forward and managed by the respective Numbered Air Forces that support specific CINCs (Commanders in Chief). Furthermore, of the resources that a unit deploys, most of the weight and volume is associated with support equipment, such as lightalls, jammers, and bobtails. Our analysis of these resources leads us to the following conclusion: *With today's support processes, policies, and technologies, deploying even a modest fighter-based combat force to a bare base will require several days of development before the Forward Operating Location can sustain a high flying tempo.* If the Air Force is to employ immediately after

deploying quickly, these resources must be provided by forward prepositioning, either at a base or at a regional support facility.

This report presents a vision of the future ACS/mobility system and addresses several options for meeting munitions, WRM, fuel, maintenance, and other support resource requirements needed for the variety of potential and uncertain scenarios that the Air Force may face. The report provides examples of how support options change with alternative employment scenarios and support technology, policies, and practices. Our goal is to foster discussion about a vision of the future ACS and mobility system that is robust in a number of potential scenarios. Developing such a vision is a complex undertaking requiring a formal integrated ACS and mobility planning process, including continuous review of the ability of ACS and mobility postures to meet defense needs as they evolve. This report also presents a framework for addressing these planning needs.

Our research indicates that the ACS/mobility system of the future will have five components:

1. Forward Operating Locations (FOLs). Some bases in critical areas under high threat should have equipment prepositioned to enable rapid deployments of heavy combat aerospace packages. They might be augmented by other, more austere FOLs that would take longer to spin up. In other parts of the world, the FOLs might all be of the second form, if conflict is not likely or humanitarian missions will be the norm.
2. Forward Support Locations (FSLs). FSLs are sites near or within an area of responsibility (AOR) for storage of munitions for WRM, or sites for consolidated maintenance and other support activities. The configuration and specific functions of FSLs depend on their geographic location, the threat, and the costs and benefits of using current facilities. Western and Central Europe are today stable and secure, and it may be desirable to use FSLs in these regions to support operations in Southwest Asia (SWA) or the Balkans (as was done to some extent in Operation Noble Anvil in Kosovo).
3. CONUS Support Locations (CSLs). CONUS depots are one type of CSL, as are contractor facilities. Other types of CSLs may be analogous to FSLs. Such support structures are needed to support CONUS forces should repair capability and other activities be

removed from units. These activities may be set up at major Air Force bases, convenient civilian transportation hubs, or Air Force or other defense repair and/or supply depots.

4. A transportation network connecting the FOLs and FSLs with each other and with CONUS, including en route tanker support. This is essential; FSLs need assured transportation links to support expeditionary forces. FSLs themselves could be transportation hubs.

5. A Combat Support Command and Control (CSC2) system to coordinate the system, organize transport and support activities, and allow the system to react swiftly to rapidly changing circumstances.

The configuration of these components depends on numerous factors. The system design will evolve as previously essential features become unneeded and are traded for other, newly important features. Therefore, a strategic planning framework is needed to help inform support system decisions. This framework needs to integrate ACS and mobility decisions and support *global* and *evolving* planning. A global perspective is needed because the combination of cost constraints, political considerations, and support characteristics may dictate that some support for a particular theater be provided from facilities in another. The configuration of FOLs and FSLs, in turn, is a critical input in sizing the airlift fleet and in setting up its refueling infrastructure to support all theaters.

Strategic planning must also evolve. The new security environment includes small, short-notice contingencies and continually changing threats. Geographic areas of critical interest will change over time, as will the threats within them. An expeditionary ACS/mobility system targeted to today's situation would be oriented toward SWA and Korea, but within a decade those regions could be at peace. In addition to the political changes, support processes and technologies will also change, as the Air Force moves to an expeditionary footing and directs its research and reengineering efforts to reducing support footprints while maintaining effectiveness. Over the next ten years, we expect to see many examples of process and technology changes, as well as political shifts, that will force reevaluations of the ACS/mobility system configuration.

In the end, these two imperatives require effective centralized planning, in which cost, political, and effectiveness tradeoffs are made for the system as a whole to ensure that each theater is appropriately protected and supported. We present a strategic planning framework based on employment-driven modeling that can be used to meet these needs. This framework needs to be embedded within the strategic ACS/mobility planning process to address the types of tradeoffs and ACS/mobility designs needed for the EAF.

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Numerous persons inside and outside the Air Force have provided valuable assistance to our work. We thank Lieutenant General John W. Handy, Jr. (AF/IL), for sponsorship and support. He has made valuable comments on the briefings of our work. General George Babbitt (AFMC/CC) also provided detailed comments on our work that helped to focus its direction.

We have enjoyed support for our research from the Air Force's Major Commands responsible for implementing the EAF. Major General Dennis Haines (ACC/XR), Brigadier General Terry Gabreski (USAFE/LG), Major General Donald Wetekam (PACAF/LG), Brigadier General Stanley Sieg (AFMC/LG), Major General Roger Brady (AMC/LG), and Colonel William Beechel (ACC/LG) provided access to personnel and data at their staff and operating locations. Colonel Michael Weitzel (CENTAF/LG) and his staff helped arrange visits to locations in Southwest Asia (SWA).

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Our research has been a team effort with the Air Force Logistics Management Agency (AFLMA). AFLMA is a partner in our overall research exploring EAF support alternatives, and its staff's assistance has been critical to the conduct of this research. We especially thank Colonel Richard Bereit (AFLMA/CC), Lieutenant Colonel Mark McConnell (AFLMA/LGM), and Chief Master Sergeant John Drew for their efforts.

Finally, we thank Colonel Rodney Boatright and Lieutenant Colonel Tony Dronkers (AF/ILXX) for their encouragement and support. At RAND, C. Robert Roll, Donald Palmer, S. Craig Moore, Louis Miller, Eric Peltz, Hy Shulman, and Amatzia Feinberg have helped with critiques of our work. Helpful and constructive formal reviews of this document were provided by RAND colleagues Chris Hanks and Major General Edward Bracken (USAF, ret.). Gina Sandberg patiently and promptly did an excellent job of preparing the document through numerous versions.

ACRONYMS

ACS	Agile Combat Support
AEF	Aerospace Expeditionary Force
AFLMA	Air Force Logistics Management Agency
AFMC	Air Force Materiel Command
AOR	Area of responsibility
APOE	Aerial Ports of Embarkation
C2	Command and control
CC	Commander
CINC	Commander in Chief
CONUS	Continental United States
CSC2	Combat Support Command and Control
CSL	CONUS Support Location
CENTAF	Air Force component of USCENTCOM
DLA	Defense Logistics Agency
EAF	Expeditionary Aerospace Force
ESTS	Electronic Systems Test Set
FOL	Forward Operating Location
FOR	Follow-On Operating Requirements
FSL	Forward Support Location
IOR	Initial Operating Requirements
JSF	Joint Strike Fighter
LANTIRN	Low Altitude Navigation and Targeting Infrared for Night
LRU	Line-replaceable unit

MICAP	Mission Incapable, Awaiting Parts
MTW	Major theater war
ONA	Opertation Noble Anvil
PACAF	Pacific Air Forces
SWA	Southwest Asia
USAFE	United States Air Forces in Europe
USCENTCOM	United States Central Command
WRM	War Reserve Materiel
WWX	World Wide Express

Chapter One

INTRODUCTION

After the Cold War, the United States found itself in a new security environment. Instead of facing known adversaries in a limited number of locations, the U.S. military has had to support numerous overseas deployments, many on short notice, with a wide range of capabilities. Deployments have been made for missions ranging from peacekeeping and humanitarian relief to major combat operations as represented by Operations Noble Anvil[1] and Desert Storm. This pattern of varied and fast-breaking regional crises appears to be the model for the foreseeable future. The U.S. Air Force has been and is likely to continue to be heavily involved in a wide variety of such operations.

The new environment has put a substantial burden on the Air Force: when operations have required land-based airpower, these needs have been satisfied by deploying both personnel and equipment to remote locations. The combination of frequent and lengthy deployments has created professional and personal turbulence for Air Force personnel. This turbulence has been linked by some to recent decreases in both retention of personnel and readiness.

To ease the burden of such deployments, the Air Force has begun to reorganize into an Expeditionary Aerospace Force (EAF). The goal of this reorganization is to replace forward presence of airpower with a force that, in response to a crisis, can deploy quickly from the continental U.S. (CONUS), commence operations immediately on arrival,

[1]Operation Noble Anvil was the name for the U.S. Air Force combat operations in Kosovo during the spring of 1999.

and sustain those operations as needed. To implement this vision, the Air Force will divide its forces into roughly ten Aerospace Expeditionary Forces (AEFs), each with a mix of fighters, bombers, and tankers, and will assign two of these to be "on-call" for crises for 90-day periods, leaving 12 months between on-call periods for each AEF. The reorganization is designed to improve deployment scheduling, balance deployment assignments among units, and reduce uncertainty associated with meeting deployment requirements.

Because the EAF concept centers on deploying combat forces from CONUS, early discussions concerning support resources focused on preparation of the deploying unit and paring unit resources to enable the deploying forces to be "light, lethal, and self-contained," or at least self-sustaining for the first few days. However, most resources needed to initiate and sustain combat operations such as munitions, fuel, and War Reserve Materiel (WRM: portable shelters, ground support equipment, and vehicles) are not unit-level resources. These resources are heavy and are usually managed by the respective Numbered Air Forces that support specific Commanders in Chief (CINCs). Furthermore, most units' resources' weight and volume are associated with support equipment, e.g., lightalls, jammers, and bobtails. Our analysis of these resources, sketched below, leads us to conclude that *with today's support processes, policies, and technologies, deploying even a modest fighter-based combat force to a bare base will require several days of development before the Forward Operating Location (FOL) can sustain a high flying tempo.* If the Air Force is to employ immediately, after deploying quickly, these resources must be prepositioned at the base or at regional facilities in quantities needed to support the employment scenario, and this network of Agile Combat Support (ACS) resources must be planned and reviewed to meet *global* strategic security requirements. Further, the design and implementation of this network will require complex tradeoffs that will be based on a combination of empirical analysis of such resources as airlift capacity and support setup timeline combined with subjective analysis of factors such as political and military risk.

This report synthesizes recent RAND research to present a vision for the ACS and mobility system that is robust against a number of scenarios and to address options for meeting requirements for munitions, WRM, fuel, maintenance, and other support resource requirements needed for potential and uncertain scenarios. We illustrate how support option characteristics change when employment scenarios, support technology, policies, and practices change. Our objective is to foster discussion about the future ACS and mobility system and about the methodology for rigorously designing and implementing the system. Developing such a vision is a complex undertaking requiring a formal integrated ACS and mobility planning process embedded in overall Air Force planning to continuously review ACS and mobility postures to meet defense needs as they evolve.

THE EAF CHALLENGE TO THE ACS/MOBILITY SYSTEM

In large part, the current ACS/mobility system, like the current combat force, was designed for the two major theater war (MTW) scenarios of the Cold War: large-scale conflicts in two well-defined locations (Europe and Korea) where air units deployed to bases with a fairly rich support infrastructure in place. Noble Anvil and Desert Storm largely fit this model because of the sophisticated infrastructure that was used by the U.S.-led coalition in Noble Anvil and because of the extensive time allowed for the coalition to enhance and extend the infrastructure in Desert Storm.

More typically in the current environment, the ACS/mobility system must support an expanded range of operations from MTWs to small-scale contingencies. These operations may take place in a variety of locations, vastly increasing planning uncertainty. This change in environment coupled with operational requirements for quick deployment, immediate employment, and indefinite sustainment means that the ACS and mobility systems need to be evaluated for possible modifications to cover the new range of operations. That evaluation has been the subject of ongoing RAND research on the EAF.

The ACS/mobility system must plan and operate on three timescales:[2]

[2]The Air Force, like the other services, uses the PPBES (Planning, Programming, Budgeting, and Execution System) to formally plan for, allocate, and expend money on resources. It also is developing and institutionalizing Air Force-specific processes for longer-range planning. We have intentionally not linked our timescales with these

- At the *execution* level (days to weeks) the ACS/mobility system must support ongoing operations with existing support resources and processes.
- At the *strategic* level (months to years) the system must acquire resources and develop processes to support evolutionary changes to the existing force structure across the full spectrum of operations in any location critical to U.S. interests, subject to peacetime cost constraints. In this time frame, alternative support practices, policies, and technologies can be developed to meet anticipated employment requirements.
- At the *long-term* level (decades) the ACS/mobility system and its strategic infrastructure must be modified to support new force structures as they come on line and may involve supporting vastly different weapon technologies.

To deal with meeting operational requirements in this changing environment, the Air Force has concentrated on the execution timescale. In contrast, our research has addressed decisions at the strategic level, which has included examining the cost and effectiveness of alternative ACS/mobility system options involving different practices, policies, and technologies across a broad range of contingencies.

ANALYTIC FRAMEWORK FOR STRATEGIC ACS/MOBILITY PLANNING

The core of our analytic framework for strategic ACS/mobility planning is a series of models of critical support processes such as munitions preparation, fuel support, maintenance, and the like that can calculate equipment, supplies, and personnel needed to meet operational requirements. Because support requirements are a direct function of mission requirements, the models are employment-

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formal processes primarily because we want to emphasize that support resources need the same integrated formal planning as do weapon systems, which has traditionally been a primary focus of the PPBES. Additionally, because the formal processes may change over time, we did not want to tie a high-level vision to irrelevant details of organization and time divisions (e.g., between planning and programming). It is clear that this framework of timescales could be mapped into the PPBES or any similar planning structure.

driven—that is, they start from the operational scenario with estimates of types and numbers of aircraft, sortie rates, types of weapons, and so forth. Once the support requirements are computed, the models can be used to evaluate options for satisfying those requirements—for example, prepositioning the equipment, deploying it from CONUS, or deploying it from regional support locations. The evaluation considers several dimensions, such as spin-up time (the time required for the deployed force to be ready to conduct operations from its deployed location), footprint (the amount of airlift capacity the deployment requires), peacetime costs (both investment and recurring), flexibility, and risks (both military and political). Figure 1.1 depicts the framework.

The primary advantage of employment-driven models is that they allow us to deal with the pervasive uncertainty of expeditionary operations. The models can be run for a variety of mission requirements selected by operators, including the support needed for different types of missions (humanitarian, evacuation, small-scale inter-

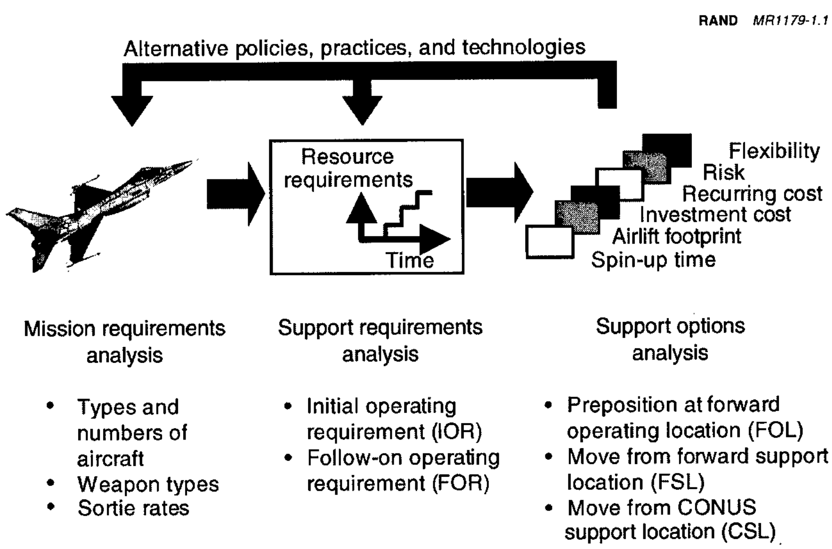

Figure 1.1—Employment-Driven Analytical Framework

diction, etc.), the effects of different weapon mixes for the same mission (new or light munitions), the effects of differing support policies, practices, and technologies, and other factors associated with supporting operations.

To use the support models in this manner, they must run quickly and estimate requirements at a level of detail appropriate for strategic decisions. This means the models must address the resources and processes that account for most of the footprint—the numbers of personnel and large pieces of equipment, such as fuel trucks, bomb loaders, cranes, and large maintenance test sets. At the same time, they must contain enough detail so that major changes to the process can be reflected in the model and evaluated in terms of their effects on different metrics. For example, one insight gained from our research is that the requirements for some support processes can be divided into Initial Operating Requirements (IOR)—the equipment, people, and supplies needed to begin operations, and Follow-On Operating Requirements (FOR)—items needed for sustainment. Being able to distinguish these in the model provides a more-flexible set of options for providing the necessary support.

The final step evaluates an option's effects on the overall metrics, including the tradeoff among moving resources from CONUS, from regional Forward Support Locations (FSLs), or prepositioning them at the FOLs from which the aircraft will fly. Mobility requirements enter the process at this step. In general, tradeoffs must be made. For example, prepositioning equipment at FOLs can reduce the spin-up time and reduce airlift footprint, but at higher costs (to preposition duplicate sets of resources at different FOLs) and possibly greater risks, if access to the equipment is subject to political or military interference.

Chapter Two

THE ACS/MOBILITY SYSTEM DESIGN TRADE SPACE

Some of the key variables affecting ACS/mobility decisions are employment options, FOL capabilities, alternative technologies, resupply times, ACS policies and practices, and mobility capabilities. Employment options affect force composition, employment timelines, and operating tempo (optempo). FOL capabilities include infrastructure and resource availability and the risks associated with prepositioning those resources at the FOL. Technology options, such as new test equipment, munitions, or support equipment, can affect requirements dramatically. Resupply time affects the initial operating requirement of resources that need to be on-hand before combat operations can begin. Alternative support policies, such as conducting repair operations at consolidated support centers rather than at the deployed unit, affect deployment and sustainment airlift requirements. Finally, mobility capacity (e.g., strategic and tactical airlift), can affect ACS solutions. To illustrate, we describe how the employment timeline, munitions and support equipment technologies, and resupply time will affect the solution direction for the ACS/mobility system.[1]

Figure 2.1 shows the relationship between the time it takes to support combat operations (the spin-up time) and alternative ways of satisfying the resource requirement. As shown in the figure, the initial operating requirement can be supplied from resources prepositioned at the FOL or moved to the FOL from an FSL or CONUS. In

[1]Much of the material in this chapter is drawn from Galway et al. (2000), which describes the analysis, the munitions, and other models.

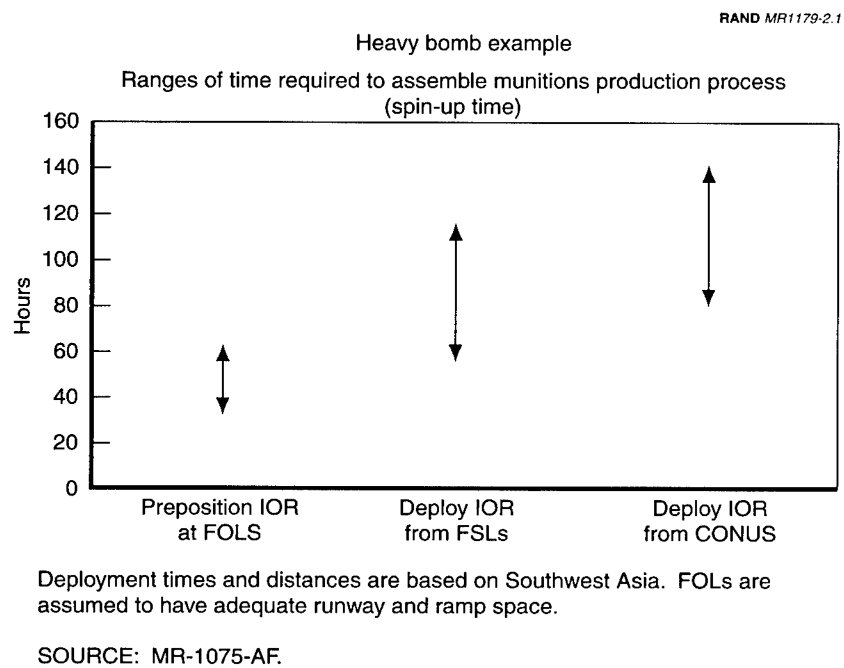

Figure 2.1—Spin-Up Time as a Function of Resource Location

this example, a munitions model was used to determine the requirements for munitions and an options analysis model was used to calculate the timelines for each alternative for satisfying the IOR for a given force that had air-to-ground mission responsibilities. Notice that the timelines are longer and have more variability when the resources are supplied from remote sources—whether from an FSL or CSL. In these cases, there are more nodes and handling required than with prepositioning the IOR at the FOL.

Figure 2.2 shows the footprint, measured in terms of C-141 equivalents, of the heavy munitions (e.g., GBU-10s) that would have to be moved to meet the IOR. In this case, the IOR was set at three days

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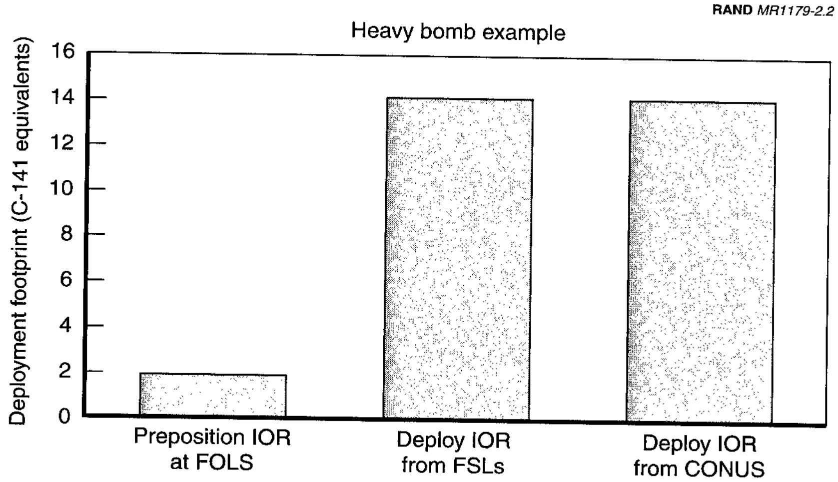


Deployment times and distances are based on Southwest Asia. FOLs are assumed to have adequate runway and ramp space.

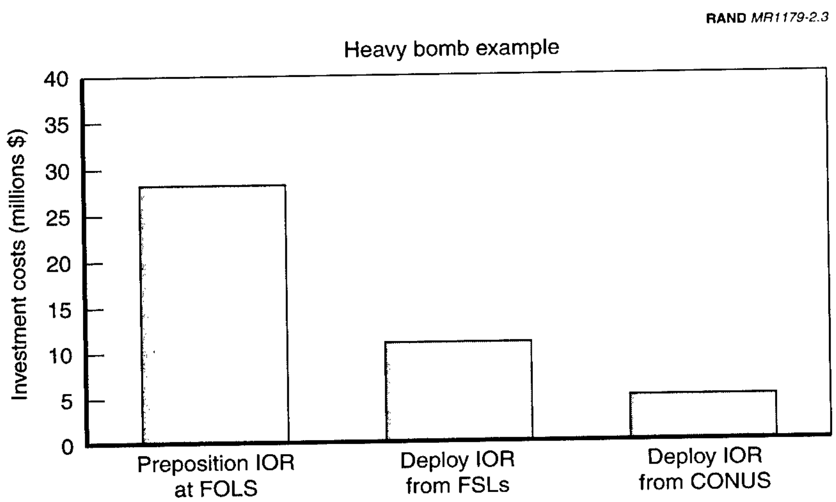
SOURCE: MR-1075-AF.

Figure 2.2—Deployment Footprint as a Function of Resource Location

and the amounts are those necessary to support 12 F-15Es flying at surge rates.[2]

Figure 2.3 shows the cost of the heavy bombs that would have to be prepositioned to support two simultaneous AEFs flying F-15Es at surge rates. The figure reflects the fact that the AEF operations might be required in two theaters. Calculations also assume that access to the FOLs is uncertain, and that five bases in each theater would have to be resourced to have a high probability of gaining access to an FOL when needed. Thus, the prepositioning option requires that heavy bomb bodies be prepositioned at ten bases.

[2]A reviewer of this report noted that recent operations have not typically flown at surge rates. We used surge rates in our analysis to present a stressing case. If planners decide that this flying rate is not probable for a particular area, our planning methods could generate investment numbers for the lower rates and some decisions might be altered.



Investment costs to cover two regions with five possible FOLs in each region. Assumes two simultaneous AEFs must be supported.

SOURCE: MR-1075-AF.

Figure 2.3—Cost of Heavy Bomb Bodies "Invested" in Each Support Option

If heavy bomb bodies are supplied from the FSL, only the IOR for four bases needs to be positioned at the FSLs. Each FSL would then have the resources to cover two AEFs (in case both operations were in a single theater). If supplying the resource from a CSL, only the resources necessary to cover the IOR investment in heavy bombs to support the two simultaneous AEFs need be stored at the designated CSL. This assumes immediate access to the resource to support AEF operations from CSLs.

Figure 2.4 illustrates the tradeoff between spin-up time and "investment cost." Prepositioning IORs at FOLs requires less movement to begin operations, leading to shorter spin-up times, but this option requires a larger materiel investment cost. The ACS design selected depends upon what the Air Force values most. There are no right or wrong answers. Decisions must be made between ACS postures with very different characteristics. Analyses such as these pro-

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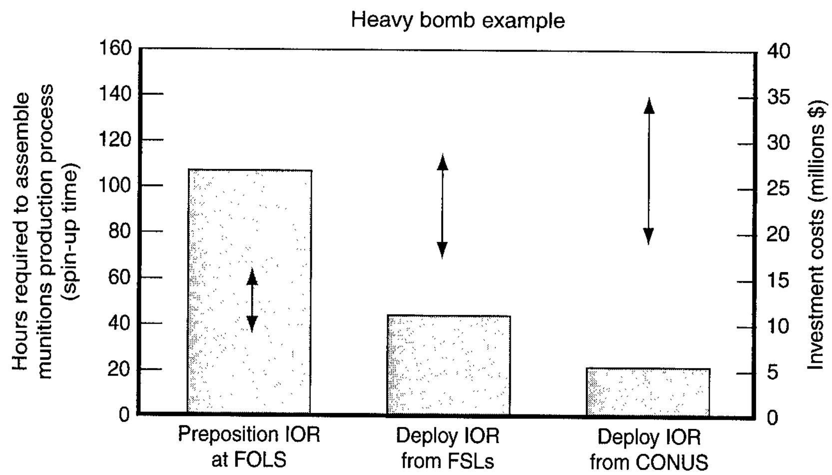

SOURCE: MR-1075-AF.

Figure 2.4—Tradeoff Between Spin-Up Time and Investment Cost

totypes are needed to inform difficult decisions on alternative resource expenditures.

Technology investment can change support option characteristics. The left panel of Figure 2.5 shows some of the equipment required to build and move heavy bombs (such as the GBU-10, which weighs 2000 lb). The right hand panel contrasts the GBU-10 (on the bottom) with a lighter "small smart munition," which is designed to attack many of the same targets against which the GBU-10 is used. This munition, if it meets the operational requirements, could reduce greatly the support footprint at an FOL.

Figure 2.6 shows the effect that this technology could have on spin-up time and deployment footprint. The technology makes storing the IOR at FSLs and CSLs competitive with prepositioning the munition at FOLs. In addition, if a fuse could be developed that would allow dense packing of the munition on aircraft, munitions-build operations may not have to take place at the FOL. This could further reduce forward deployment requirements and spin-up time.

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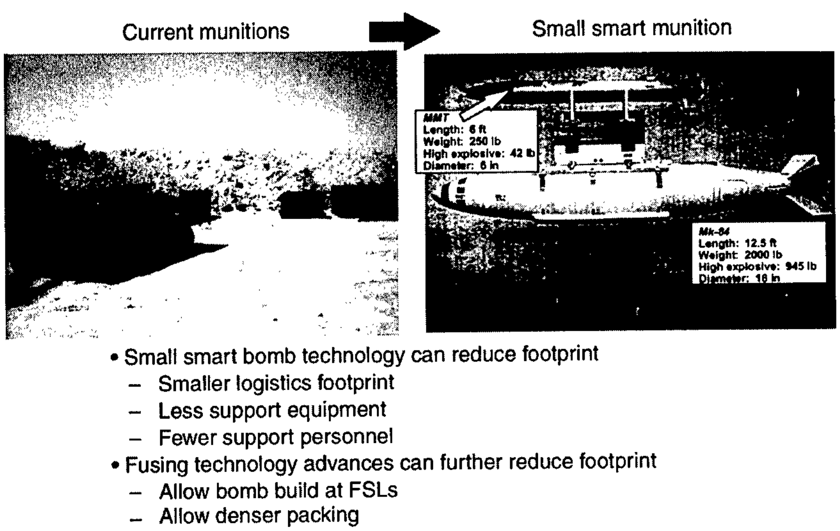

Figure 2.5—Small Munitions Characteristics

Support policy options significantly affect EAF efficiency. In Figure 2.7, we show some results of our F-15 avionics analysis, in which we compared the effects of differing maintenance policies on deployment footprint (among other things). We also compared the effects of alternative tester technology under the differing maintenance support options. The left side of the figure shows the effects of consolidating intermediate avionics maintenance activities. Some 700 people would need to deploy in a two-MTW scenario under the current policy of deploying intermediate maintenance capability with the deploying units.

If maintenance activities were to be consolidated at three or five regional facilities (two to four FSLs for theater support plus one CSL, denoted as "2R+C" in Figure 2.7), the deployment requirements would drop to around 100 persons. These people would deploy from the CSL to the FSLs rather than to FOLs as under current policy to handle the increased workload. If the entire force were supported by one CSL, there would be no deployment requirements. If support was consolidated, the support to the deployed force would be de-

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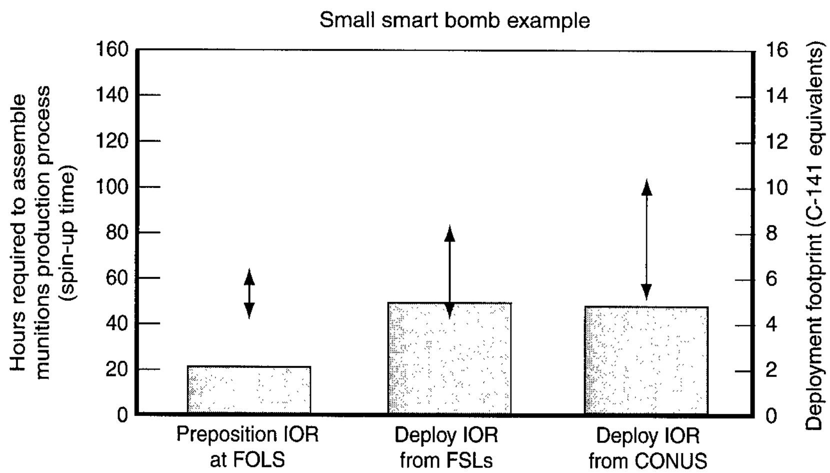


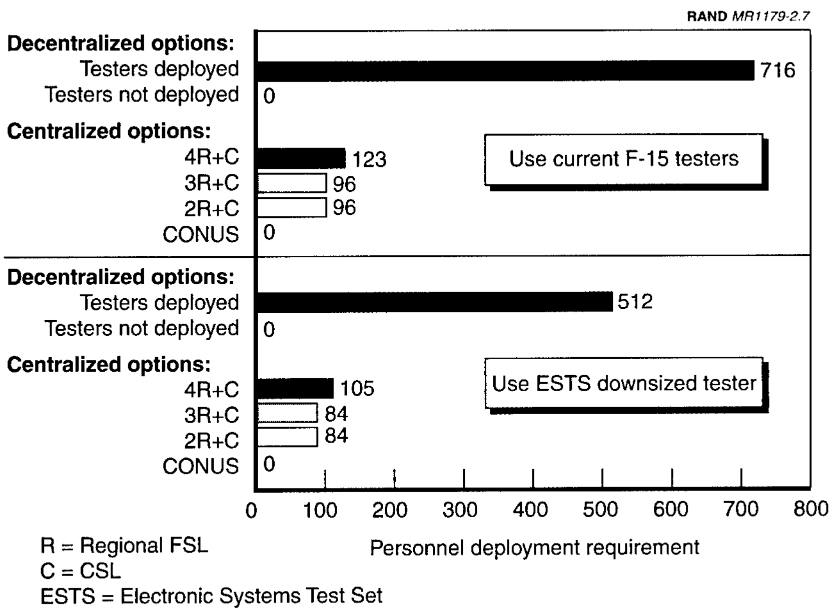
Deployment times and distances are based on Southwest Asia. FOLs are assumed to have adequate runway and ramp space.

SOURCE: MR-1075-AF.

Figure 2.6—Effect of the Small Smart Munition on Spin-Up Time and Deployment Footprint

pendent upon assured transportation and additional spares may be required to cover the pipelines between units and their FSLs or CSL. Again, tradeoffs must be made in designing the future ACS system.

The right side of Figure 2.7 shows the effects on personnel deployment of acquiring the F-15 downsized tester—the Electronic Systems Test Set (ESTS). In this case, the investment in ESTS technology reduces the deployment footprint by approximately 200 people if the Air Force continues its current decentralized approach to F-15 intermediate-level avionics repair. However, notice that this technology does not cut personnel deployment requirements as much as does a change in policy from decentralized to consolidated repair. Consolidated maintenance does not require as many testers because of economies of scale and better utilization rates of equipment. Thus, technology may not reduce footprint under



NOTES: Boiling peacetime (small AEF) deployments do not require deployment of maintenance personnel to FSLs. Base-case deployments are to FOLS. Deployments to FSLs are augmentees from CONUS.

Figure 2.7—Personnel Deployment Requirements for F-15 Avionics Support Options

existing policies as much as would a change in policy itself. Again, our analysis shows that an organized and structured approach is needed to evaluate how alternative policies, practices, and technologies affect EAF operations.

Resupply time can also affect ACS design options. It is a major determinant of the IOR for commodities, such as munitions that need to be prepositioned at FOLs to support immediate employment of forces. As the resupply time is cut, the amount of IORs and the initial deployment requirements can also be decreased. Resupply time also affects the choice of repair process locations—whether forward at FOLs, at consolidated points within the theater, or at consolidated points within CONUS. If resupply time is long, maintenance equipment and personnel either have to be deployed with the units to keep them operational or large quantities of spare parts will be needed to fill longer pipelines to and from the units and their sources of repair. Beyond reducing cost and thereby making consolidated repair feasible, short resupply times are effective in dealing with uncertainties brought about by the inability to predict requirements or by changes in requirements resulting from enemy actions. A short resupply time provides the ability to react quickly to inevitable surprises, thereby mitigating their effects.

To illustrate the importance of resupply time in the decision of where to locate repair processes and to get a rough idea of what is feasible in the near term, we turn to two separate studies we have made on maintenance support in an expeditionary environment: the repair of LANTIRN (Low Altitude Navigation and Targeting Infrared for Night) pods[3] and of F-15 avionics.[4] Both of these studies examined a range of maintenance structures from forward, decentralized repair to consolidated repair, either in the theater or CONUS, over a range of potential resupply times. Essentially, they both show the resupply time breakpoints at which consolidated repair becomes preferable (in terms of aircraft supportability and/or cost) to decentralized, forward repair.

We start by examining what we might expect resupply times to be for theaters where the United States has vital interests. What will these resupply times be in wartime or during crises? The future ACS system needs to be designed around realistic wartime resupply times, not peacetime resupply possibilities. Figure 2.8 shows theoretical and empirical curves that illustrate the resupply performance for a number of current transportation alternatives.[5] The left-most curve

[3]Forthcoming report by Amatzia Feinberg, Hyman L. Shulman, Louis Miller, Eric Mazlik, and Robert S. Tripp.

[4]Forthcoming report by Eric Peltz, Hyman L. Shulman, Robert S. Tripp, Timothy L. Ramey, Randy King, and John Drew.

[5]All of the distributions in Figure 2.8 are for nonbackordered shipments. These curves examine the capability of the distribution system. Of equal concern to the effectiveness of consolidated maintenance, though, is whether items are on the shelf ready to be shipped at the consolidated repair location when required by FOLs. High backorder rates would shift the upper portion of each curve substantially to the right (which is why these curves may appear much better than performance normally experienced in the Air Force today). The stockage requirements calculated from the ex-

(AMX-C Sim) in Figure 2.8 shows the theoretically optimum distribution of expected resupply times for small items (e.g., 150 lb or less) that could be shipped via express carriers to Southwest Asia (SWA) from CONUS using AMX-C/BDS.[6] This distribution includes the entire resupply time, including the time from requisition submission to receipt of the item by base supply, and has a mean of about four days (including weekends, holidays, and pickup days). This curve was generated from a simulation model of the AMX-C plan and current Air Force and joint processes; it uses optimistic times for materials handling and customs, assumes no queueing resulting from resource constraints,[7] and allows no delays for weather, mechanical problems, or enemy action. It represents a "current process optimum" to points within SWA.

The next curve (ONA DLA MICAP) shows the empirical distribution of resupply times for MICAP (mission incapable, parts) requisitions filled from the Defense Logistics Agency (DLA) during Operation Noble Anvil (ONA). Although this represents a mixture of transportation modes, most went by World Wide Express (WWX).[8] It is the current best case—the requisitions are high priority, the dominant transportation mode uses an established commercial network, and the source is a high-volume shipping facility. This curve shows that the system can approach the AMX-C simulation for the bottom half of the distribution. However, its longer "tail" shows the real-world variability resulting from resource constraints and delays (e.g.,

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pected pipeline lengths and the safety stock levels determined from availability objectives need to be satisfied.

[6]AMX-C/BDS is a system planned for wartime distribution of small items. AMX-C would bring small packages via military and commercial transportation within the United States to a U.S. hub, where a civilian contractor would consolidate the shipments for overseas transportation (either military or civilian, depending on destination and threat levels). At the overseas destination, BDS (battlefield distribution system) would deliver the shipments in the theater.

[7]Everything in the commercial CONUS aerial ports of embarkation (APOEs) at the time of scheduled daily departure gets on the aircraft. The same occurs at all transshipment points. The theater distribution system is considered to consist of trucks; the trucks picking up material at the theater hub arrive randomly but without resource constraints.

[8]WWX is a Department of Defense (DoD) contract with commercial express carriers to move small items within CONUS and from CONUS to the rest of the world. The contract specifies guaranteed in-transit delivery times for shipments between specific locations.

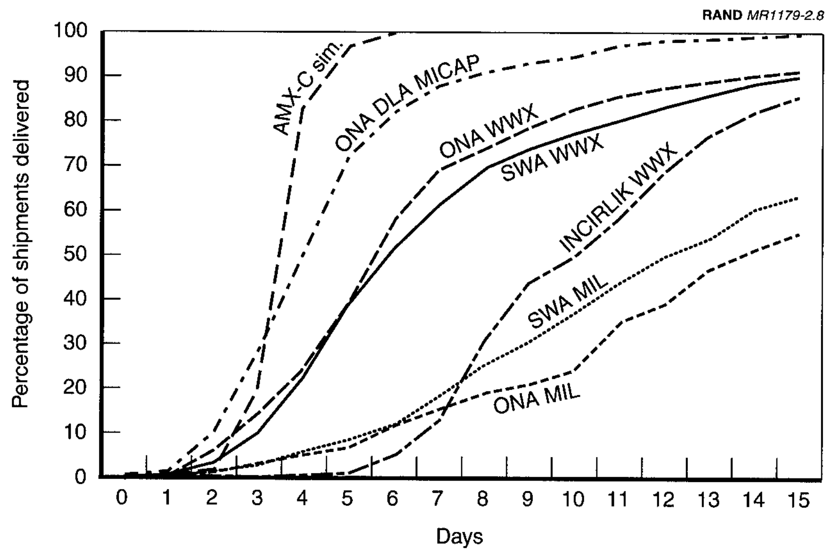

Figure 2.8— Empirical and Theoretical Resupply Times for Various DoD Transportation Channels

weather) not included in the simulations. The next two curves (ONA WWX and SWA WWX) show the distribution of WWX deliveries to ONA and to current deployments in SWA. They give a good indication of current WWX capabilities to areas with well-established distribution networks. The next curve (WWX Incirlik) is the current distribution of resupply time via WWX to Incirlik, Turkey, and shows that current WWX performance can be somewhat worse to locations other than SWA and Western Europe. The final two curves (ONA MIL and SWA MIL) show the distribution of resupply times to ONA and SWA of shipments of "big and ugly" cargo carried by military air. (Other analyses of military air shipments show that these curves are representative of the current performance of this transportation mode). These last curves are relevant to the following discussion of LANTIRN transportation needs, because LANTIRN pods are both heavy and contain classified components that require either military transport or escort by a cleared courier.

DoD recently established a resupply time goal of five days to overseas locations and directed that inventory levels be adjusted downward to reflect these new goals. These empirical and theoretical curves indicate that in the very best circumstances this goal to overseas FOLs can be met for small items in wartime environments, but they also indicate that even to a theater as close and well developed as Europe the current system does not meet the goal for all shipments of small items. And it is vital to remember that, even in the best of circumstances, the system can barely achieve the goal without backorders.

We can now examine the LANTIRN pod and F-15 avionics studies against this resupply analysis. For LANTIRN targeting pods, we require a resupply time of two days (for getting a serviceable pod from the repair facility) to provide pod availability equivalent to having the repair capability at the operating base. The timeline is very short because of the lack of spare pods, and no new buys of the targeting pod are planned. This resupply time is clearly out of reach from CONUS based on the times in Figure 2.8 (and might even be a stretch for in-theater transportation). However, deployment of LANTIRN repair capability to FOLs is not an attractive option because the test equipment used is heavy and can be unreliable when moved. If intratheater distribution can achieve two days, then consolidation at a regional facility may be the best option, but beyond that, deployment of repair capability to FOLs would likely be necessary.

For F-15 avionics, the situation is much more complex because the Air Force is still buying spares, and comparison of consolidated repair options must take into account the cost of spares to cover longer pipelines. However, consolidation of repairs at regional or CONUS facilities sharply reduces personnel, as well as the need for some upgrades currently being considered to repair equipment. Our analysis shows that the resupply time from consolidated repair facilities to FOLs must be under about five days or the longer pipeline will require substantial investments in new spares to maintain capability. Data from theater support of MICAP requisitions show that transportation times from regional FSLs could meet this time,[9] but Figure

[9]Data collected from AEW 4 deployment to Doha, Qatar, from May 1997 to August. MICAP requisitions that were processed at Prince Sultan Air Base in Saudi Arabia averaged less than five days. At that time, Prince Sultan Air Base and Doha were con-

2.8 shows that transportation from CONUS might not be fast enough.[10]

Models of individual support processes can yield insights into the functioning of these processes for expeditionary operations. To plan for an ACS/mobility system, we need to integrate the outputs of models of different processes and consider mixes of options, such as prepositioning some material, deploying other material from FSLs, and deploying still other material from CONUS. Research continues on this topic, and we are exploring the use of optimization techniques to help integrate support options.

Before summarizing some of our findings, we note that a potential operation may be found to be unsupportable from a process capability or a cost standpoint. Senior leaders may then devise an alternative operational strategy that would achieve their goals but with a lower cost or risk. Our framework is therefore not just for ACS/mobility analysis; it encompasses an integrated analysis of operations, ACS, and mobility.

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nected by scheduled military resupply flights. During ONA, resupply time from RAF Lakenheath (UK) to F-15 FOLs in Italy averaged about two days for avionics Line-Replaceable Units (LRUs).

[10]However, the research indicates that even if the wartime resupply could achieve this breakpoint, the peacetime cost of operating only consolidated CONUS repair locations would be significantly higher than today's cost. The number of peacetime aircraft collocated with repair locations can be as important as the resupply time in some cases. With regional repair locations, several wings could be collocated with peacetime repair locations versus only one wing with consolidated CONUS repair.

Chapter Three

KEY FINDINGS

Our use of the analytic framework and prototype models for specific commodities has made clear the broad characteristics of the ACS/mobility system required to support expeditionary operations for the current force. The most important finding of our research is that the Air Force goal of deploying a nominal expeditionary package (a 36-ship mixed fighter squadron of air defense suppression, air superiority, and ground-attack aircraft) within 48 hours to an unprepared bare base cannot be met with today's support processes. That timeline can be met only with judicious prepositioning, and even then only under optimistic assumptions.

Figure 3.1 shows the results of using a prototype integrating model for munitions, fuel, vehicles, and shelter for a ground-attack scenario using the above force package. The model recommended positioning at FOLs, FSLs, or CONUS for each commodity based on three target timelines, while minimizing peacetime cost. The 48-hour timeline requires substantial materiel prepositioned at the FOL. In contrast, a bare base could be used if (1) the timeline were extended to 144 hours and (2) the materiel were prepositioned at an FSL. Little support can be provided from CONUS even by accepting a longer timeline.[1]

[1]These timelines assume that airlift is available for moving the aerospace force as needed. Other demands, such as moving Army units or humanitarian supplies could divert airlift resources in any given contingency at the discretion of the CINC and would increase the time required to close this force.

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	Forward operating location	Forward support location	CONUS
48 hours	Bombs (IOR) Fuel FMSE Shelter Vehicles	Missiles (IOR & FOR) Bombs (FOR) Repair: avionics and engines	Unit equipment
96 hours	Bombs (IOR) Fuel Shelter Vehicles	Bombs (FOR), FMSE Repair: avionics and engines	Unit equipment Missiles (IOR & FOR)
144 hours	Fuel	Bombs (IOR & FOR) Repair: avionics and engines Shelter Vehicles	Unit equipment Missiles (IOR & FOR) FMSE

Deployment times and distances are based on Southwest Asia. FOLs are assumed to have adequate runway and ramp space. FMSE = Fuel Mobility Support Equipment.

SOURCE: MR-1075-AF.

Figure 3.1—Cost/Timeline Resource Allocation Tradeoff

These commodities are heavy and require substantial transportation to move them. The timeline and the strategic airlift working area constraints that we used in our analysis did not allow the material to arrive in time.[2] Moving these commodities requires large numbers of vehicles and materials handling equipment such as forklifts, trailers, and other large vehicles. The current Harvest Falcon shelter package for bare bases requires 100 C-141 loads to move and almost four days to erect with a 150-man crew. Because so much airlift is needed to move the equipment, unloading space for airlift at the FOL becomes a key constraint on how fast the deployment can be executed.

[2]The Maximum On Ground (MOG) was set at two for FOLs. This may be reasonable for FOLs such as Al Jabbar Air Base in Kuwait, Azrac Air Base in Jordan, and Sheik Isa Air Base in Bahrain.

This does not mean that expeditionary operations are infeasible. Rather, it means that setting up a strategic infrastructure to perform such operations involves a series of complicated tradeoffs. Expensive 48-hour bases may best be reserved for areas of the world that are critical to U.S. interests and are under serious threat, such as in SWA or Korea. In other areas, a 144-hour response may be adequate; deployment to such areas could be supported from suitably chosen FSLs. In still other areas such as Central America, most operations are humanitarian relief missions, which could be accomplished with a 48-hour timeline to a bare base because much of the heavy equipment required for combat operations would be unnecessary. For all of these cases, the models and analytic framework can help decisionmakers negotiate the complex webs of strategic infrastructure decisions.

Note that FSLs appear in the solution set regardless of the FOL employment time. They provide a cost-effective method of providing forward storage of heavy commodities and maintenance of commodities that require large and heavy maintenance equipment repair. The Air Force already uses FSLs for munitions and WRM storage. The Buffalo Soldier, a munitions ship, is an example of an FSL afloat. Sanem Luxembourg is an FSL dedicated to WRM storage. Consolidated regional repair centers have also been established to support recent conflicts. During Desert Storm, C-130 engine intermediate maintenance was consolidated at Rhein Main Air Base for all C-130s participating in that operation. During Noble Anvil, intermediate avionics repair was established at RAF Lakenheath (UK) to support F-15s assigned to the operation.

Chapter Four

OVERVIEW OF A GLOBAL ACS/MOBILITY SYSTEM

Based on our preliminary results, we can begin to envision an evolving ACS/mobility system that will support expeditionary operations over the foreseeable future. The system would be global and have elements forward-based (or at least located outside of CONUS). Figure 4.1 gives a notional picture of what such a support system would look like. The system aims to be geographically robust (cover the globe) and concentrates some facilities in areas of current national security concern (SWA and Korea).

The system has five components:[1]

1. FOLs. Some bases in threatened critical areas should have equipment prepositioned to enable rapid deployments of heavy combat aerospace packages. The FOLs might be augmented by other, more austere FOLs that would take longer to spin up. In other parts of the world, the FOLs might all be of the second form if conflict is not likely or if humanitarian missions will be the norm.
2. FSLs. FSLs are sites near or within an area of responsibility (AOR) that serve as places to store munitions for WRM or as places for consolidated maintenance and other support activities. The configuration and specific functions of FSLs depend on their geo-

[1]Components 4 and 5 are the subject of ongoing RAND research and will be dealt with comprehensively in future reports. We note especially that assured transportation is a contentious issue. By doctrine, the CINC controls theater distribution and airlift resources are limited (much is in the Reserve or Guard), which adds an additional complication to lengthy operations.

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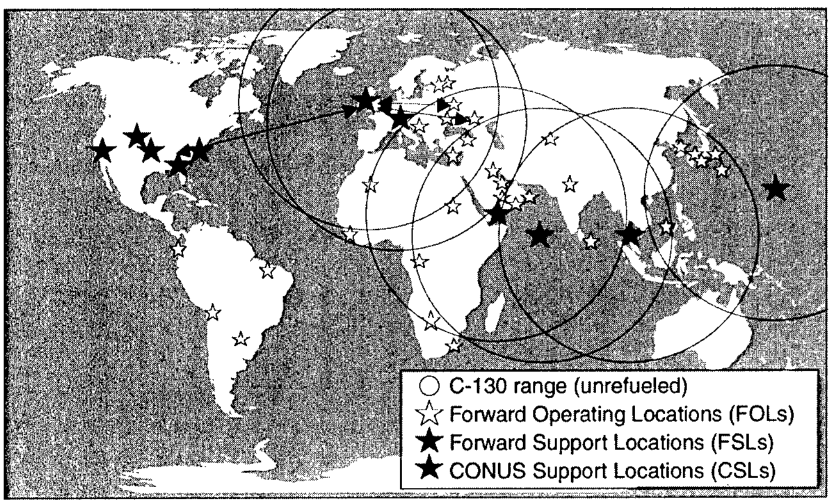


Figure 4.1—Notional Global ACS Network

graphic location, the threat, and the costs and benefits of using current facilities. Western and Central Europe are currently stable and secure, and it may be possible to support operations in areas such as SWA or the Balkans from FSLs in these areas.

3. CSLs. CONUS depots are one type of CSL, as are contractor facilities. Other types of CSLs may be analogous to FSLs. Such support structures are needed to support CONUS forces because some repair capability and other activities may be removed from units. These activities may be set up at major Air Force bases, convenient civilian transportation hubs, or Air Force or other defense repair and/or supply depots.

4. A transportation network connecting FOLs and FSLs with each other and with CONUS, including en route tanker support. This is essential; FSLs need assured transportation links to support expeditionary forces. FSLs themselves could be transportation hubs.

5. A logistics command and control (C2) system. To coordinate the ACS/mobility system—to organize transport and support ac-

tivities—and to allow the system to react swiftly to rapidly changing circumstances, we believe that a C2 system would be needed, because many support resources would not be under the direct command of the supported units.

The configuration of these components will depend on numerous factors. The system's primary focus should be on areas of vital U.S. interests that are under threat. Figure 4.2 shows a notional configuration of FOLs and FSLs to support the Caucasus region. In this hypothetical situation, some FOLs have been designated as 48-hour FOLs to receive initial forces and commence operations immediately. Other FOLs have longer timelines for employing forces. In other areas, the threat may not be time-critical (e.g., it does not include armored attack over an unobstructed corridor), so the FOLs may be 96-hour bases or 144-hour bases. Actual locations will depend on factors such as in-place infrastructure and force protection, political aspects (e.g., access to bases and resources), and how site locations affect future alliances and host-nation relationships. The analytical framework introduced here needs to be expanded and linked with methods for taking these additional issues into account.

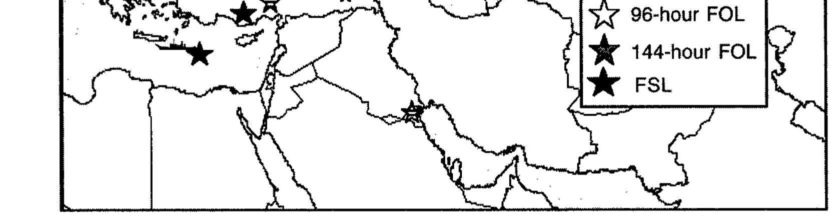


Figure 4.2—A Notional FOL/FSL Configuration to Support the Caucasus Region

We emphasize that this potential structure and our key findings are dependent on the characteristics of the force and support processes. Our findings to date are driven to a large extent by the characteristics of the current force and support processes. As new policies and practices are formulated and implemented, as the Air Force gains experience with expeditionary operations, and as new technologies for ground support, munitions, shelter, and the like become available, many of these decisions will need to be revisited and the support system configuration adjusted to reflect the new capabilities. Improvements in transport times, weight, and equipment reliability may shift the balance in favor of supporting operations from CONUS and shrinking the network of FSLs.

An advantage of the analytic framework is that it helps to focus research and attention on areas where footprint reductions could have big payoffs. Munitions is a key example: Reductions in weight and assembly times could pay large dividends in speed of deployment. For operations at bare bases, shelter is also crucial and heavy. Changes in these areas will not be made immediately, however, and the structure outlined above will enable expeditionary operations in the immediate future.

From these analyses, and the preliminary results of others in progress, we infer that expeditionary operations with the current force and with current support processes requires judicious prepositioning of equipment and supplies at selected FOLs, backed by a system of FSLs that can provide equipment storage and maintenance services. Such a system would also require a transportation system to link the FOLs and FSLs.

Peacetime cost is an important concern in our analysis. The new support concept may help contain costs by consolidating assets, reducing deployments for technical personnel (who could be assigned to FSLs for tours of duty), using host-nation facilities, and possibly sharing costs with allies. Further, considerable infrastructure including buildings and large stockpiles of WRM may already be available in developed areas such as Europe.

Chapter Five

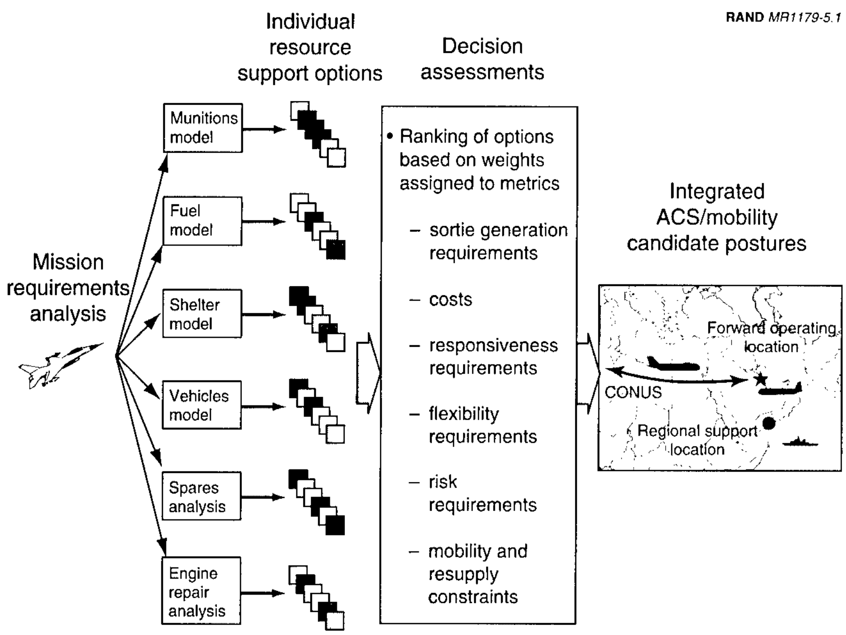
STRATEGIC AND LONG-TERM PLANNING FOR THE ACS/MOBILITY SYSTEM

Developing an ACS/mobility system that can best support EAF operations requires many decisions about prepositioning, the location of FOLs and FSLs, and the location of various support processes. Figure 5.1 shows an expanded view of our analytic framework in which the outputs from the individual models of Figure 1.1 are combined to produce candidate integrated support postures for all resources.[1]

Strategic plans for ACS/mobility must be both *global* and *evolving*. A global perspective, not one focused on an individual theater, is needed because the tradeoff among cost constraints, political considerations, and support characteristics may dictate that some support for a particular theater or subregion be provided from facilities in another. This is not a theoretical point: Because much of the critical SWA theater is politically volatile, support to that region might better be provided from outside (as indeed, some is now from bases in Europe and on Diego Garcia Island, which is part of the Pacific theater). The configuration of FOLs and FSLs, in turn, is a critical input in sizing the airlift fleet and in setting up its refueling infrastructure, both of which must support all theaters.

Strategic planning must also adapt to changing circumstances. As we noted at the outset, the new security environment includes small,

[1]The material in this chapter is drawn from a more extensive discussion in MR-1056-AF.



SOURCE: MR-1056-AF.

Figure 5.1—A Structured Modeling Framework for Integrated ACS/Mobility Decisions

short-notice contingencies and continually changing threats. Geographic areas of critical interest will change over time, as will the specific threats within them. An expeditionary ACS/mobility system that is targeted to today's situation would be oriented toward SWA and Korea, but within a decade those regions could be at peace. In addition to the political changes, support processes and technologies will change, as the Air Force moves to an expeditionary footing and directs its research and reengineering efforts to reducing the support footprint while maintaining effectiveness. For example, replacing older, heavy munitions with the small smart munition would make airlifting munitions more feasible and reduce the need for prepositioning (the greater cost of the small munition would also favor central storage). Over the next ten years, we expect to see many examples of process and technology changes, as well as political shifts, that will force reevaluations of the ACS/mobility system configuration.

In the end, global and evolving planning requires that operational and logistical leaders make a number of difficult decisions, on a recurring basis, in which cost, political, and effectiveness tradeoffs are made for the system as a whole to ensure that each theater is appropriately protected and supported. This goes against the current practice of each theater commander controlling all theater resources. Peacetime cost considerations alone seem to require that facilities not be duplicated unnecessarily across theaters.

Figure 5.2 illustrates the nature of tradeoff analyses that can be facilitated using the modeling framework described above. In general, there is no "right" answer; rather, decisionmakers must pick from a set of ACS options that meet the employment timelines for various areas and affordability criteria (based on the importance of the area

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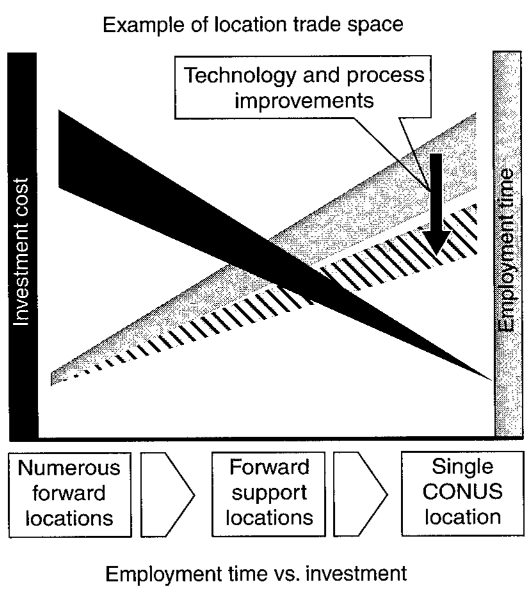

Figure 5.2—Notional Tradeoff Analysis

and the urgency of the threat). For some critical areas under high threat (e.g., SWA today), the need for fast employment may require forward positioning of support resources and the acceptance of significant investment costs. However, new technologies and process improvements may shift these tradeoff curves to lessen costs, reduce prepositioning, or both.

Changes in the force will also require changes in the support structure. The F-22, for example, is designed to have one-half the support footprint of the F-15. The Joint Strike Fighter (JSF) is also designed to reduce support requirements. Air Force wargames, particularly the Future Capabilities games, have experimented with radically different forces that rely on standoff capabilities or space-based weapons. All of these developments will change support requirements and, therefore, the options that are attractive under peacetime cost constraints.

The advantage of the analytic framework we are developing is that long-term changes can be handled in the same way as shorter-term modifications to policy and technology. New technologies, political developments, and budget changes will require continuous reassessment of the support system's configuration. New force structures will bring different demands for support resources, and support options must correspondingly shift.

For long-term decisions, the quick-turn, exploratory nature of strategic analysis is even more important. For example, what if the F-22 does not reduce support requirements? New support options can be compared with the current system, and plans can be made for a graceful transition, perhaps conditional on future information or political developments.

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